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D4 Digital Channel Bank Family:

The Maintenance Bank

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The D4 Maintenance Bank (D4MB) is a centralized facility for testing D4 channel units as well as a place for the hot monitored spare of all common equipment used in the D4 channel bank. At least one D4MB equipped with D4 channel units is recommended for each office. The D4MB contains a test set and two digroups of common equipment that simulate the D4 digital system. When a channel unit needs to be tested, it is inserted in the test position of the D4MB and the craftsperson tests it by following simple instructions listed on 3x5 plastic cards. These tests are performed on any given code of channel unit, usually without changing any options in the channel unit under test. Voice-frequency (VF) and signaling tests are performed on the channel unit under test. These tests assure the craftsperson that the unit under test will not affect or impair the transmission of other channel units already installed in working D4 channel banks. The D4MB is an inexpensive and simple D4 plug-in unit test vehicle for craft use. It has proven extremely reliable in determining whether a unit is good or defective. Testing with the D4MB has greatly increased the office personnel's confidence in both channel units and common units that are to be used in a working D4 channel bank. As a result, significant cost savings have been realized using the D4MB by virtually eliminating unnecessary shipping and retesting of good units that might have been previously returned to the factory for repair.

I. INTRODUCTION

With each generation of D-type channel banks, the testing and maintenance facilities have been improved. In the D3 system, a shelf

of "hot spare" common equipment was used with special electronic circuits built into the bank to localize trouble in a specific plug-in unit. With the D4 channel banks, additional maintenance testing features have been developed. The most notable development is the D4 Maintenance Bank (D4MB). The D4MB is a channel unit test set and a common equipment monitoring facility for use in offices where D4 channel banks are installed. It can be used in any centralized testing facility where a -48 volt connection is available. The D4MB contains two Maintenance Bank Test Sets (MBTSs), two complete digroups of D4 common equipment, and one four-Wire E and M (4EM) channel unit. The MBTS is used for testing D4 channel units and for monitoring the performance of the common equipment. The monitored common equipment plug-ins may be used as "safe operable" units for restoring service to a failed D4 bank. The common units are also used in the D4MB to generate the appropriate pulse code modulation (PCM) and timing control signals for testing channel units. The common units function as if they were in a working D4 system. Figure 1 shows a D4MB fully equipped with common equipment and MBTS plug-in units.

II. FUNCTIONS OF MAINTENANCE BANK

2.1 Common equipment monitoring

There are three main functions for which the D4MB can be used: hot spare monitoring, quick check of any D4 unit, and channel-unit testing. The hot spare monitoring function ensures that common units installed in the D4MB are good. Figure 2* shows a typical monitoring mode of operation. In the monitoring mode, the MBTS supplies a 1020-Hz tone to a Channel-Unit Simulator (CU SIM) in the MBTS into a looped digroup of common equipment and then through a second tandem digroup of looped common equipment through a 4EM channel unit. The 1020-Hz tone level out of the 4EM channel unit is monitored by the MBTS voice-frequency level-detector. An alarm is generated by a Maintenance Bank Alarm Unit (MB ALM) if the monitored output level is not within ±0.5 dB of its nominal level. This alarm can be disabled manually by a switch on the MB ALM. While there are certain types of failure in D4 common plug-in units that would not be detected in this monitor mode, the message transmission path including the coder, decoder, clock circuits, and the Line Interface Unit (LIU) multiplexing and demultiplexing circuits are verified as being operative. Therefore, these common plug-in units can be used in an office as new units to correct trouble in a D4 channel bank and restore service.

* Acronyms and abbreviations used in the figures are defined at the back of this issue.

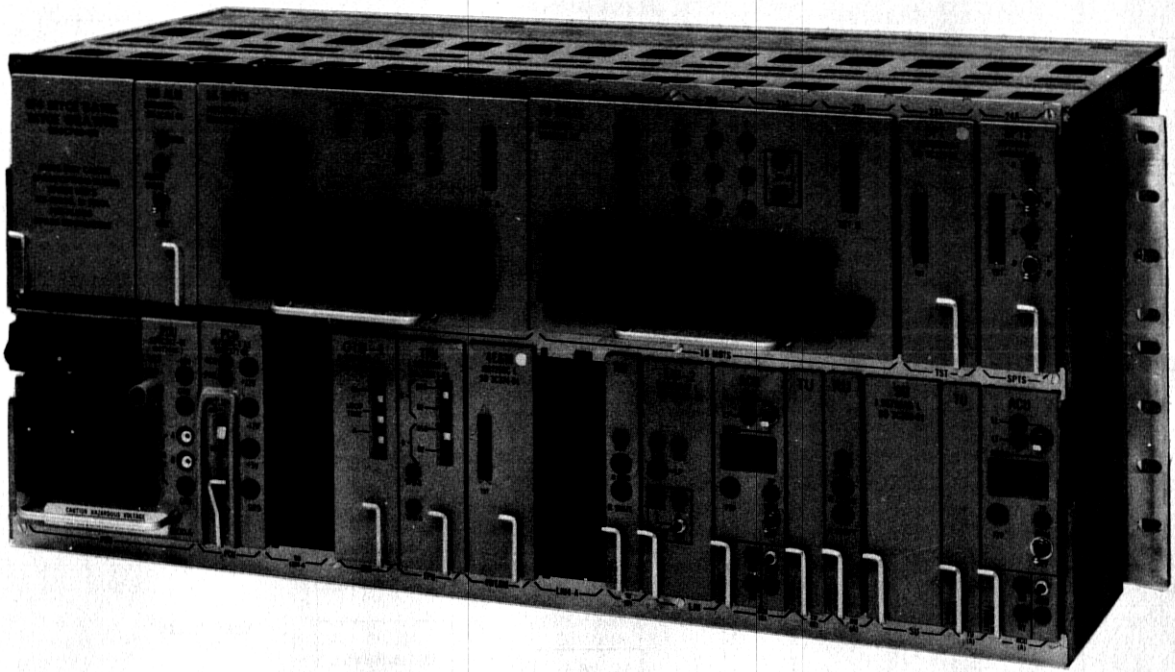

Fig. 1—A fully equipped D4MB with common equipment and MBTS plug-in units.

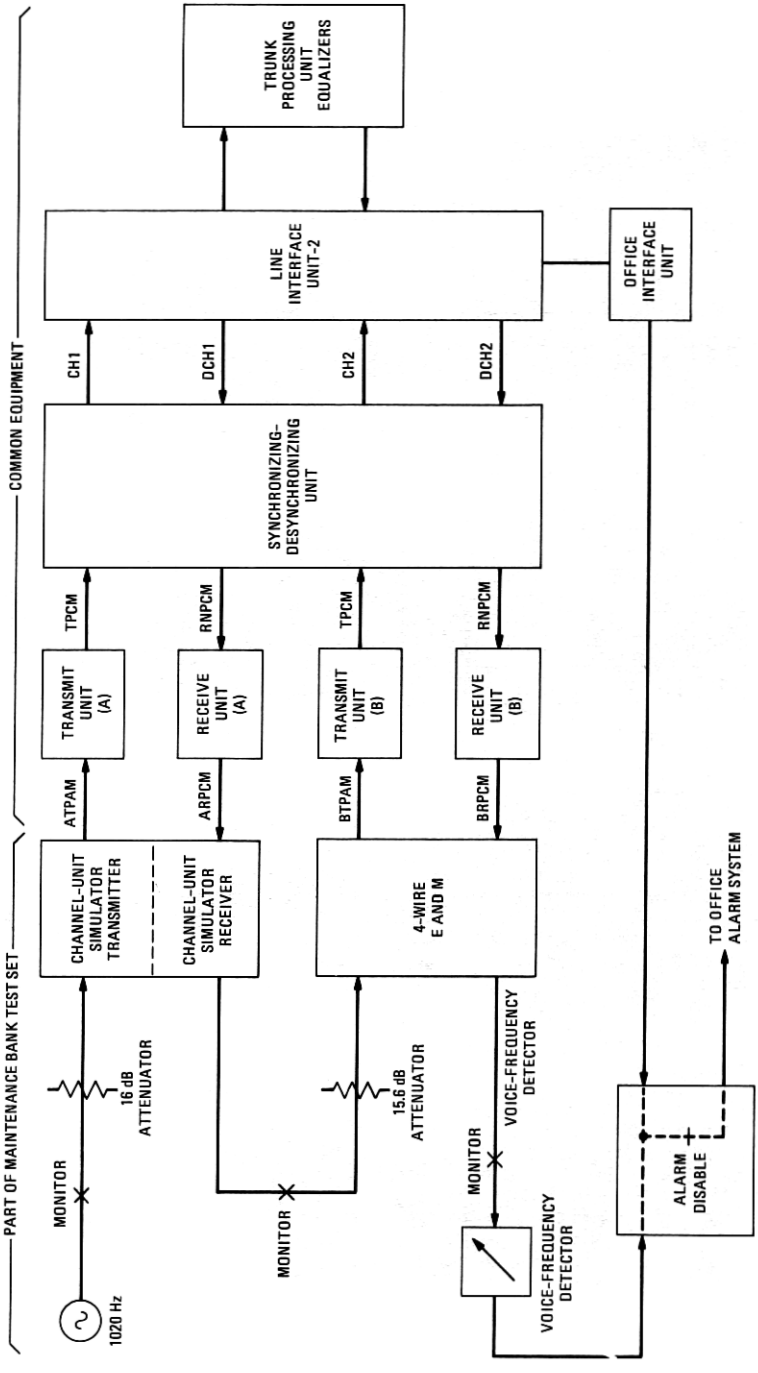

Fig. 2—D4MB monitoring arrangement.

2.2 Testing of ancillary circuits

The D4MB can quickly check a plug-in unit suspected of having a malfunction in a nontransmission-affecting circuit, e.g., alarm circuit. The maintenance bank is a complete D4 channel bank except for the absence of a full complement of channel units. Thus, with ancillary D4 test equipment, it forms a vehicle for performing any D4 test.

2.3 Testing of channel units

The D4MB can also test channel units. This test capability was previously not included in the maintenance equipment for earlier D-type banks. Channel units should be tested in the D4MB if there is any reason to suspect that a unit might be faulty. The test is made to ensure that other channels in a working bank will not be impaired by having a faulty channel unit inadvertently plugged into an in-service bank. The D4MB can also be used in the isolation of an end-to-end transmission of signaling troubles. Figures 3 and 4 show how the D4MB is arranged for channel-unit testing. The transmit and receive sides of the channel units are checked individually. The tests include the drop-side circuits (hybrids, signaling bridge, etc.) of the channel unit. These tests are more complete than previous D-type bank tests although less stringent than tests made at the faceplate four wirepoint. The tests performed on a D4 channel unit are:

(*i*) Loss (or gain) of the transmit portion of a channel unit at 1020 Hz.

(*ii*) Loss (or gain) of the receive portion of a channel unit at 1020 Hz.

(*iii*) Noise and crosstalk introduced into all adjacent time slots from the channel-unit transmitter.

(*iv*) Noise or crosstalk introduced into the channel-unit receiver from the other 23 time slots.

Items (*iii*) and (*iv*) above are called multichannel (MC) interference tests. These tests provide assurance that a newly installed channel unit will not impair the performance of other channels in an in-service D4 bank.

All channel unit tests are made by inserting the unit to be tested in the channel under test (CUT) position. Simple instructions for each code of channel unit to be tested are listed on a 3x5 plastic card. The tests consist of emulating all circuit conditions and displaying the results using LEDs.

III. MAINTENANCE BANK TEST SET CIRCUITS

The MBTS contains the circuit functions necessary to test both directions of transmission and signaling in D4 plug-in units. The following is a brief description of the MBTS circuits.

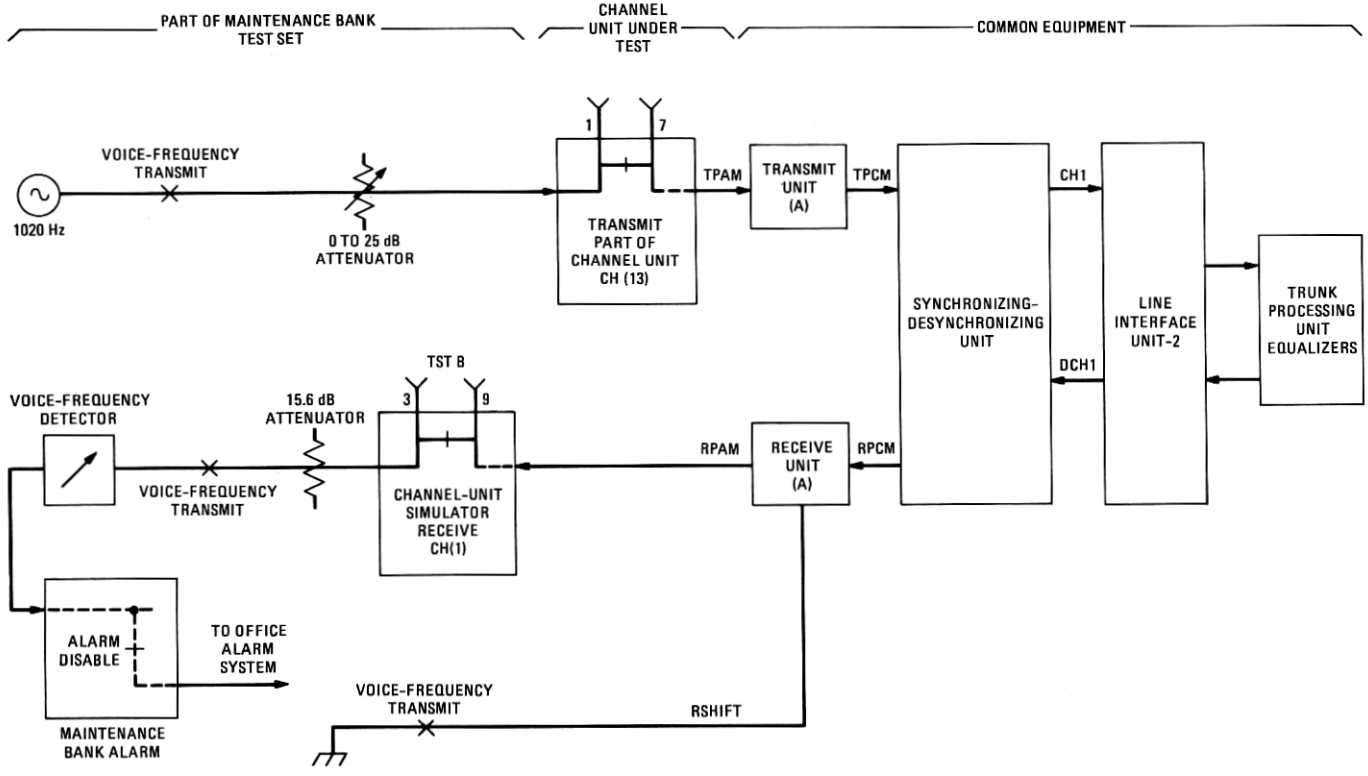

Fig. 3—D4MB voice-frequency transmitting (shown for Mode 2).

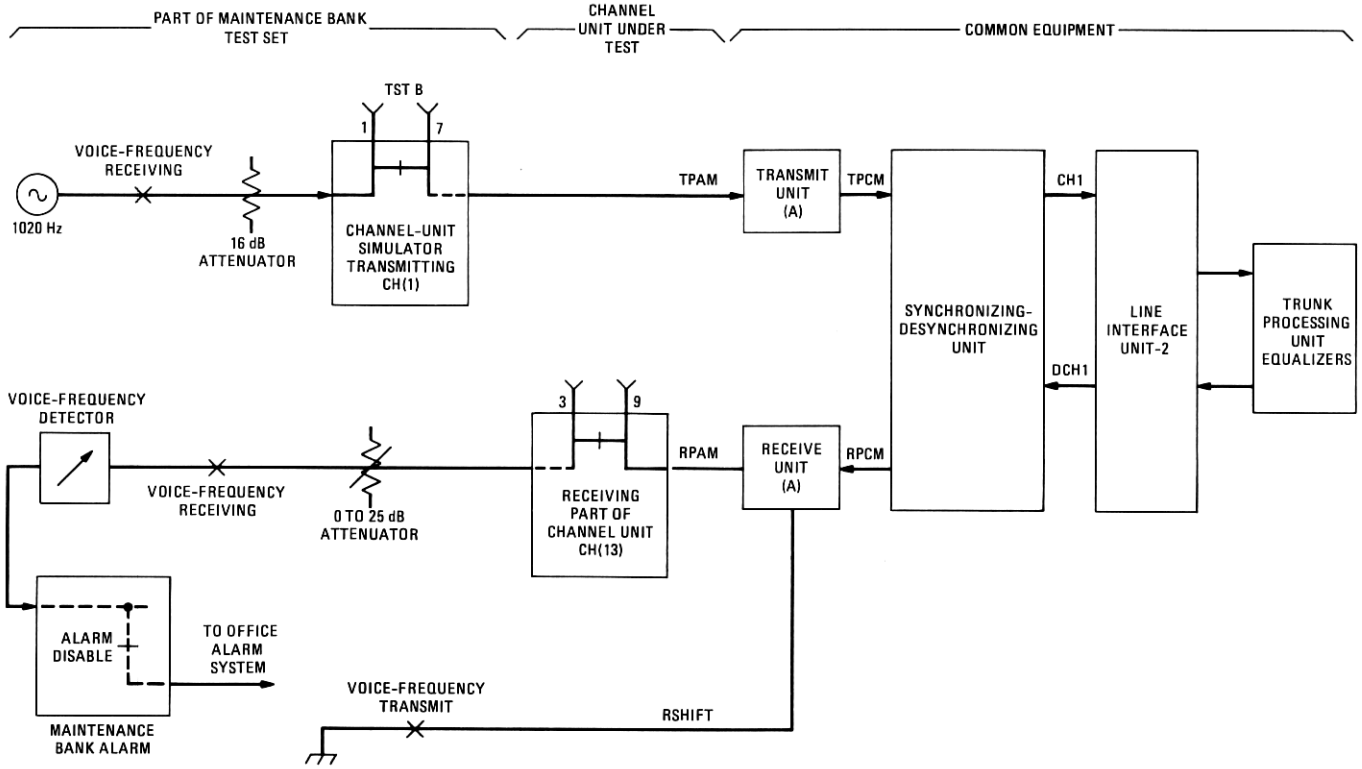

Fig. 4—D4MB voice-frequency receiving (shown for Mode 2).

3.1 VF oscillator

The VF oscillator circuit provides an extremely stable 1020-Hz sine wave for use in testing transmission levels and performing multichannel interference measurements.

3.2 Transmit and receive attenuators

A channel unit to be tested can have a variety of installed loss, depending on the office being served. Variable attenuators controlled by switches on the face of the MBTS are used to complement the installed loss in the channel unit so that these units can be tested at standard transmission levels.

3.3 Channel-unit simulator

The MBTS channel-unit simulator is essentially a D4 channel unit. This CU SIM is assigned to the channel 1 time slot while the channel unit under test is assigned to time slot 13. These two time slots were chosen so that the application of the R-SHIFT feature in the receive unit permits the CU SIM to communicate with the D4 channel unit under test.

3.4 VF-level detector

In the VF test mode, the voice-frequency-level detector compares the internally generated 1020-Hz test tone level with the tone received from the channel unit under test. If the two levels are within ±0.5 dB, a green (PASS) LED lights up. This same circuit is also used similarly during the monitor mode operation. In the monitor mode, it not only illuminates a monitor LED but it also triggers the MB ALM if the monitored level falls out of the ±0.5 dB range.

3.5 Multichannel detector (MC)

In the multichannel tests, analog and digital circuit functions are combined to simulate an interference signal. This signal is sent through the channel unit and the output is monitored. When the level of this interference power in the channel unit under test is less than -45 dBm0, a green LED (MC PASS) lights up. When the interference power in the channel unit is greater than -45 dBm0, a red MC FAIL LED lights up.

3.6 Signaling circuits

The signaling circuits apply steady-state signaling conditions to the channel unit under test. These signaling conditions are controlled by switches on the faceplate of the MBTS. Application of prescribed signaling conditions cause the channel unit under test to output steady-state signals to the signaling detectors.

3.7 Signaling detector circuits

The signal detector circuits interpret the signaling conditions delivered by the channel unit under test and illuminate LEDs on the front of the MBTS corresponding to these signaling states. The signaling condition and the corresponding LED display of the signaling states are given on the test card.

3.8 Alarm circuits

Alarms are processed in the maintenance bank alarm circuit when either the Monitor (MON) LED is not lit or when the Power Distribution Unit (PDU) indicates that the D4 common equipment failed and is in an alarm condition. Two contact pairs operate the office minor alarm audible and visual alarms. An alarm also lights up the maintenance bank alarm (MBA) LED on the face of the alarm unit. This outgoing alarm can be disabled by the ALARM DISAB switch. A yellow LED lights up on the MB ALM unit to indicate that the office alarm from the D4MB has been disabled. The ALARM DISAB switch is used to inhibit office alarms from the D4MB when channel units are being tested or when common equipment from the D4MB is being used to restore service in a failed D4 bank.

3.9 Control switches

Pushbutton switches on the MBTS control transmission and signaling conditions. Each D4 channel unit to be tested has information on instruction cards to indicate how to set the switches and what kind of LED response to expect for transmission and signaling tests.

IV. INSTRUCTION CARDS

Any standard D4 channel unit can be tested by following the instructions on a 3x5 index card for that particular code of channel unit. A craftsperson simply operates switches and compares the lighted LEDs with the indications on the instruction cards. There are more than 32 codes of channel units, each of which contains various options that can be tested with these instruction cards. Figure 5 shows a typical instruction card for voice-frequency and signaling tests.

V. LINE INTERFACE MODES OF D4MB OPERATIONS

The maintenance bank can be operated in any of the five D4 modes by equipping it with appropriate plug-in modules. This is accomplished by simply plugging in the appropriate LIU and, when necessary, a synchronizing-desynchronizing Syndes Unit (SU). Any one of the Office Interface Units (OIUS) can be placed in the bank. The operation and selection of plug-in units for the maintenance bank will be determined

SDPO SIG TESTS 3/78

OPTIONS: NONE CARD 1 OF 1

TEST	SWITCHES 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	LAMPS A	B	C	D	E	F	G	H	J	20 Hz
1.01																				A					F		H	J	
1.02				4																A					F	G			
1.03							7															C	D				H	J	
1.04						6			9																				
1.05	1					6			9											A						G			
1.06		2				6			9											A						G			
1.07																													
1.08																													
1.09																													
1.10																													

SDPO VF TESTS 3/78

1. OPERATE SWITCH ON MB ALM UNIT TO ALARM DISAB POSITION.
2. EXAMINE T ATTENUATOR IN CU TO BE TESTED AND DEPRESS TRMT ATTEN SWITCHES ON 1A MBTS WHICH CORRESPOND TO ATTENUATOR SECTIONS WITH A WHITE JUMPER PLUG IN THE ZERO SIDE.
3. EXAMINE R ATTENUATOR IN THE CU AND REPEAT INSTRUCTION 2 FOR THE RCV ATTEN SWITCHES.
4. TEST THE VF PORTION OF THE CU BY DEPRESSING THE SWITCHES AS INDICATED IN THE TABLE BELOW AND NOTE THE APPROPRIATE LAMP INDICATIONS.
5. IF THE CU FAILS ONE OR MORE OF THE TESTS, FOLLOW INSTRUCTIONS ON VF CALIBRATION CARD.

TEST		SWITCHES 7	9	10	11	12	13	14	15	16	17	18	19	LAMPS VF CAL	MON	TRMT	RCV	MC PASS	FAIL
2.01	VF XMT			10					15							TRMT			
2.02	VF RCV			10						16							RCV		
2.03	MC XMT			10			13											PASS	
2.04	MC RCV		9	10				14										PASS	

Fig. 5—D4MB test cards.

by the local operating personnel. This mode should be the same as is used in D4 banks in the office. Where more than one mode is used in an office, each mode can be monitored from time to time so as to be reasonably sure of having a "safe operable" LIU of the proper type on hand. The D4MB should be kept fully equipped with two digroups of common equipment. When one of these plug-in units is used for restoral, a D4 channel unit should be replaced in the D4MB with another unit.

VI. TESTING DATAPORT CHANNEL UNITS

The D4MB was originally designed to test only standard channel units and some early varieties of special service channel units. A recent modification was made to the D4MB back plane wiring to accommodate

testing of the new D4 dataport channel units in conjunction with readily available digital data test equipment. This equipment is the KS 20908, KS 20909 Data Test Sets, and the ED-3C792-31 Test Interface Unit. The modification is a required change to remove a voltage that could damage dataport channel units that are plugged into the CUT position of the D4MB. Further, the change provides an integrated clock signal from the OIU-2 in the D4MB. Since this change was initiated during the last quarter of 1980, a check should be made before dataport channel units are plugged into the D4MB. All D4MB's modified to accommodate dataport channel units are identified by the list numbers "WD" or "WE" stamped on the side of the shelf framework next to the J-code numbering.

VII. SPECIAL SERVICE CHANNEL UNITS

Some special service channel units, such as those with gain transfer, cannot be tested with the levels installed in that unit. The test card for the special service units with nonstandard ranges of transmission levels specify an exact amount of loss to be installed in that channel unit for testing. Also, not all special service units have signaling that can be fully tested in the D4MB.

VIII. PHYSICAL INFORMATION

The D4MB is completely self-contained and can be mounted individually or with D4 channel banks in a shop-assembled bay. It contains two shelves of plug-in units and occupies approximately 9-½ inches vertically on a 23-inch bay. Figure 1 shows a D4MB fully equipped with plug-in units for two D4 digroups of common equipment and one 4EM channel unit. The D4MB may be equipped for any of the D4 operating modes. The upper shelf has storage for the Signaling Path Test Set, a drawer for small maintenance parts and tools, and three Maintenance Bank Test Set plug-in units.

IX. SUMMARY

The D4MB is a monitoring system for ensuring that a set of "safe, operable" D4 common plug-in units is available for service restoral. It also can test channel units for defects that would impair service in a working bank. Furthermore, it is a simple-to-use test set and readily available in every D4 office. The D4MB has proven to be a useful tool for testing D4 units and has significantly reduced the number D4 units that might have been previously assumed bad and returned for repair.

REFERENCES

1. C. R. Crue et al., "The D4 Digital Channel Bank Family: The Channel Bank," B.S.T.J., this issue.
2. W. G. Albert et al., "D4: Up to Date Channel Bank for Digital Transmission Plant," Bell Lab Rec., *55,* No. 3 (March 1977), pp. 66-72.
3. T. J. Aprille et al., "The D4 Digital Channel Bank Family: Dataport—Channel Units for DDS Subrates," B.S.T.J., this issue.